

Materials Design Analysis Reporting (MDAR) Checklist for Authors

The [MDAR framework](#) establishes a minimum set of requirements in transparent reporting mainly applicable to studies in the life sciences.

eLife asks authors to **provide detailed information within their article** to facilitate the interpretation and replication of their work. Authors can also upload supporting materials to comply with relevant reporting guidelines for health-related research (see [EQUATOR Network](#)), life science research (see the [BioSharing Information Resource](#)), or animal research (see the [ARRIVE Guidelines](#) and the [STRANGE Framework](#); for details, see *eLife*'s [Journal Policies](#)). Where applicable, authors should refer to any relevant reporting standards materials in this form.

For all that apply, please note **where in the article** the information is provided. Please note that we also collect information about data availability and ethics in the submission form.

Materials:

Newly created materials	Indicate where provided: section/figure legend	N/A
The manuscript includes a dedicated "materials availability statement" providing transparent disclosure about availability of newly created materials including details on how materials can be accessed and describing any restrictions on access.		No new materials were created. Viral vectors were purchased.

Antibodies	Indicate where provided: section/figure legend	N/A
For commercial reagents, provide supplier name, catalogue number and RRID , if available.		N/A

DNA and RNA sequences	Indicate where provided: section/figure legend	N/A
Short novel DNA or RNA including primers, probes: Sequences should be included or deposited in a public repository.		N/A

Cell materials	Indicate where provided: section/figure legend	N/A
Cell lines: Provide species information, strain. Provide accession number in repository OR supplier name, catalog number, clone number, OR RRID.		N/A

Primary cultures: Provide species, strain, sex of origin, genetic modification status.		
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Experimental animals	Indicate where provided: section/figure legend	N/A
Laboratory animals or Model organisms: Provide species, strain, sex, age, genetic modification status. Provide accession number in repository OR supplier name, catalog number, clone number, OR RRID.	Methods Section – Subjects Adult male (250–275g) and female (200–225g) Sprague Dawley rats (Charles River Laboratory, Wilmington, MA). Animals were housed on a 12h light/dark cycle with food and water ad libitum. Viral vector: AAV5-CaMKII α -ChR2(H134R)-eYFP (UNC viral vector facility; titer $\sim 10.0 \times 10^{12}$ particles/ml).	
Animal observed in or captured from the field: Provide species, sex, and age where possible.		N/A

Plants and microbes	Indicate where provided: section/figure legend	N/A
Plants: provide species and strain, ecotype and cultivar where relevant, unique accession number if available, and source (including location for collected wild specimens).		N/A
Microbes: provide species and strain, unique accession number if available, and source.		

Human research participants	Indicate where provided: section/figure legend) or state if these demographics were not collected	N/A
If collected and within the bounds of privacy constraints report on age, sex, gender and ethnicity for all study participants.		N/A

Design:

Study protocol	Indicate where provided: section/figure legend	N/A
If the study protocol has been pre-registered, provide DOI. For clinical trials, provide the trial registration number OR cite DOI.		N/A

Laboratory protocol	Indicate where provided: section/figure legend	N/A
Provide DOI OR other citation details if detailed step-by-step protocols are available.	Methods sections — Surgeries, Behavioral methods, Ex vivo electrophysiology. Detailed step-by-step protocols for oxycodone self-administration, forced abstinence, optogenetic stimulation, and whole-cell patch-clamp recordings are described in the Methods section.	

Experimental study design (statistics details) *		
For in vivo studies: State whether and how the following have been done	Indicate where provided: section/figure legend. If it could have been done, but was not, write “not done”	N/A
Sample size determination	Methods — Statistical Analysis. Sample sizes were determined based on previously published studies using similar opioid self-administration and electrophysiology protocols. Post-hoc power analyses were conducted for intrinsic excitability comparisons and are reported in the Results section and figure legends.	
Randomisation	Methods — Statistical Analysis. Male and female rats were randomly assigned to either saline or oxycodone self-administration groups.	
Blinding	Methods — Behavioral methods. Somatic withdrawal behaviors were scored by a researcher who was unaware of treatment assignments.	
Inclusion/exclusion criteria	Methods — Catheter patency was verified weekly; animals with failed catheters were excluded from self-administration data. For electrophysiological recordings, cells were excluded if access resistance exceeded 20 MΩ during the recording, to ensure recording quality and data	

	integrity. Less than 15% of Neurobiotin-stained neurons identified as non-MSNs (sparsely spined or aspiny neurons) were excluded from morphological analysis, as these cell types were outside the scope of the present study.	
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Sample definition and in-laboratory replication	Indicate where provided: section/figure legend	N/A
State number of times the experiment was replicated in the laboratory.	Results and Figure Legends — The number of animals and cells per group is reported throughout the Results section and in all figure legends.	
Define whether data describe technical or biological replicates.	Data represents biological replicates (individual animals and cells).	

Ethics	Indicate where provided: section/submission form	N/A
Studies involving human participants: State details of authority granting ethics approval (IRB or equivalent committee(s), provide reference number for approval.		N/A
Studies involving experimental animals: State details of authority granting ethics approval (IRB or equivalent committee(s), provide reference number for approval.	Methods (Subjects) All animal procedures were conducted in accordance with the guidelines of the National Institutes of Health and were approved by the Institutional Animal Care and Use Committee (IACUC) at McLean Hospital/Harvard Medical School (Protocol #2017N0000277, #2018N000090 & #2017N000125).	
Studies involving specimen and field samples: State if relevant permits obtained, provide details of authority approving study; if none were required, explain why.		N/A

Dual Use Research of Concern (DURC)	Indicate where provided: section/submission form	N/A
If study is subject to dual use research of concern regulations, state the authority granting approval and reference number for the regulatory approval.		N/A

Analysis:

Attrition	Indicate where provided: section/figure legend	N/A
Describe whether exclusion criteria were pre-established. Report if sample or data points were omitted from analysis. If yes, report if this was due to attrition or intentional exclusion and provide justification.	Results and Figure Legends. All data generated were included in the figures. For behavioral data, animals that failed catheter patency checks were removed from self-administration analyses as pre-established exclusion criteria. For electrophysiological data, cells were excluded if access resistance exceeded 20 MΩ during recording, as a pre-established quality-control criterion. Less than 15% of Neurobiotin-stained neurons identified as non-MSNs (sparsely spined or aspiny neurons) were excluded from morphological analysis, as these cell types were outside the scope of the present study.	

Statistics	Indicate where provided: section/figure legend	N/A
Describe statistical tests used and justify choice of tests.	Methods (Statistical Analysis) Statistical analyses were performed using GraphPad Prism 9 and MATLAB R2025b. Behavioral data were analyzed using Mixed-effects models (REML), Two-way and Three-way ANOVAs with Sidak's multiple comparisons, and two-tailed t-tests as appropriate. EPSC amplitude input-output data were analyzed using Three-way ANOVA (Light × Drug × Sex) in GraphPad Prism 9; an additional linear mixed-effects model (LME) analysis accounting for the nested structure of the data (cells within animals) was conducted in MATLAB and yielded consistent conclusions, confirming robustness of findings to analytical approach. IPSC amplitude data were analyzed using linear mixed-effects models (LME) with REML estimation, fitted separately for males and females, to account for repeated measurements across light intensities nested within animals and multiple cells	

	recorded per animal. Spike count-current relationship data were analyzed using nested hierarchical Poisson generalized linear mixed-effects models (GLMMs) fitted separately for each sex and abstinence duration, with random intercepts and slopes at the animal level and random intercepts for cells nested within animals. Choice of statistical approach was justified based on the hierarchical structure of electrophysiological data. Exact F-statistics, degrees of freedom, and p-values are reported throughout the Results section. Data are presented as mean $\pm$ SEM.	
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Data availability	Indicate where provided: section/submission form	N/A
For newly created and reused datasets, the manuscript includes a data availability statement that provides details for access (or notes restrictions on access).	All raw data supporting the findings of this study are deposited in the Dryad Digital Repository https://doi.org/10.5061/dryad.wwpzm13 . Data includes per-animal and per-cell measurements for behavioral, electrophysiological, and morphological datasets reported in the manuscript.	
When newly created datasets are publicly available, provide accession number in repository OR DOI and licensing details where available.		N/A
If reused data is publicly available provide accession number in repository OR DOI, OR URL, OR citation.		N/A

Code availability	Indicate where provided: section/figure legend	N/A
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For any computer code/software/mathematical algorithms essential for replicating the main findings of the study, whether newly generated or re-used, the manuscript includes a data availability statement that provides details for access or notes restrictions.	All statistical analyses were performed using GraphPad Prism 9 and MATLAB R2025b. No custom code beyond standard toolbox functions was used. MATLAB scripts are available upon reasonable request to the corresponding author.	
Where newly generated code is publicly available, provide accession number in repository, OR DOI OR URL and licensing details where available. State any restrictions on code availability or accessibility.		N/A
If reused code is publicly available provide accession number in repository OR DOI OR URL, OR citation.		N/A

Reporting:

The MDAR framework recommends adoption of discipline-specific guidelines, established and endorsed through community initiatives.

Adherence to community standards	Indicate where provided: section/figure legend	N/A
State if relevant guidelines (e.g., ICMJE, MIBBI, ARRIVE, STRANGE) have been followed, and whether a checklist (e.g., CONSORT, PRISMA, ARRIVE) is provided with the manuscript.	Animal research was conducted and reported in accordance with the ARRIVE guidelines. Sex as a biological variable was included in all experimental designs and analyses, consistent with NIH guidelines on sex inclusion in preclinical research.	

* We provide the following guidance regarding transparent reporting and statistics; we also refer authors to [Ten common statistical mistakes to watch out for when writing or reviewing a manuscript](#).

Sample-size estimation

- You should state whether an appropriate sample size was computed when the study was being designed
- You should state the statistical method of sample size computation and any required assumptions
- If no explicit power analysis was used, you should describe how you decided what sample (replicate) size (number) to use

Replicates

- You should report how often each experiment was performed
- You should include a definition of biological versus technical replication
- The data obtained should be provided and sufficient information should be provided to indicate the number of independent biological and/or technical replicates
- If you encountered any outliers, you should describe how these were handled
- Criteria for exclusion/inclusion of data should be clearly stated
- High-throughput sequence data should be uploaded before submission, with a private link for reviewers provided (these are available from both GEO and ArrayExpress)

Statistical reporting

- Statistical analysis methods should be described and justified
- Raw data should be presented in figures whenever informative to do so (typically when N per group is less than 10)
- For each experiment, you should identify the statistical tests used, exact values of N, definitions of center, methods of multiple test correction, and dispersion and precision measures (e.g., mean, median, SD, SEM, confidence intervals; and, for the major substantive results, a measure of effect size (e.g., Pearson's r , Cohen's d))
- Report exact p-values wherever possible alongside the summary statistics and 95% confidence intervals. These should be reported for all key questions and not only when the p-value is less than 0.05.

Group allocation

- Indicate how samples were allocated into experimental groups (in the case of clinical studies, please specify allocation to treatment method); if randomization was used, please also state if restricted randomization was applied
- Indicate if masking was used during group allocation, data collection and/or data analysis